

# **Technology Performance Risk Measure**

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**May 10, 2006**

**Multi-Dimensional Assessment of Technology Maturity Workshop**

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# Outline

- General Problem Statement
- Why is This a Problem for DoD?
- Specific Problem Statement
- Hypothetical Example
- Technology Performance Risk Measure:  
Methodology
- Case Study Examples
- Next Steps



# General Problem Statement

- DoD Weapon System Failures are Attributed to Premature Transfer of Technology
- Current DoD Methods to Determine Technology Readiness are Inadequate
  - Insufficient Measures to Assess Technology Readiness
  - Lack of Quantifiable and Comparable Risk Assessments
- Maturity, by Itself, is Inadequate to Determine Transition Readiness
- Unmet Performance is Insufficient Measure of Risk

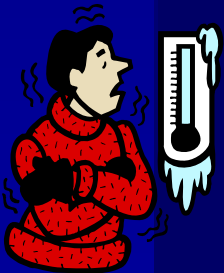


# Why is this a Problem for DoD?

- Environment: Technology Development Separated from Weapon System Development
  - Different Priorities
  - Different Perspectives
- Inconsistent Application of TRLs
- Unique Technology Assessments
- Qualitative
- Immature Transition of Technology Leads to Significant Cost and Schedule Impacts Upon DoD Weapon Systems

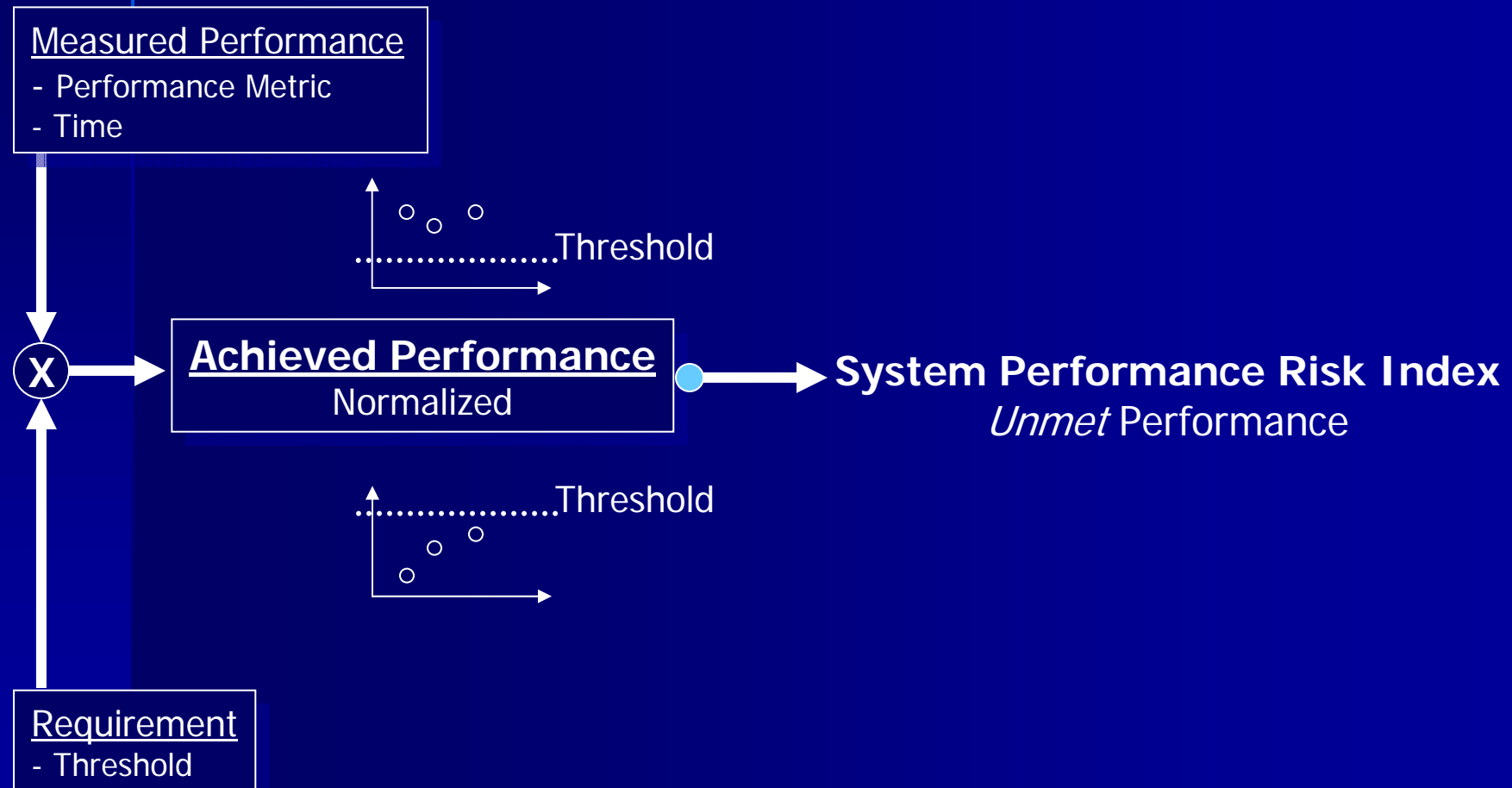
# What We Know & Need to Know

- At TRL 3, Technologists Know:
  - Who.....Customers
  - What.....Requirements
  - When.....Schedule
  - How.....Program Plan
- In Addition, Technologists **NEED** to Know:
  - How Well.....**PERFORMANCE & RISK**
- While a Thermostat Measures Actual Temperature, the Wind Chill Factor is More of Concern
- The Proposed Methodology for Calculating Technology Performance Risk Measure Provides More Realistic Measure of the Actual Performance Risk, Just as the Wind Chill Factor Does for Temperature.



# System Performance Risk Index

*Garvey & Cho, Spring 2003*



Garvey, Paul R. and Cho, Chien-Ching, "An Index to Measure a System's Performance Risk", Acquisition Review Quarterly, Spring 2003.



# Specific Problem Statement

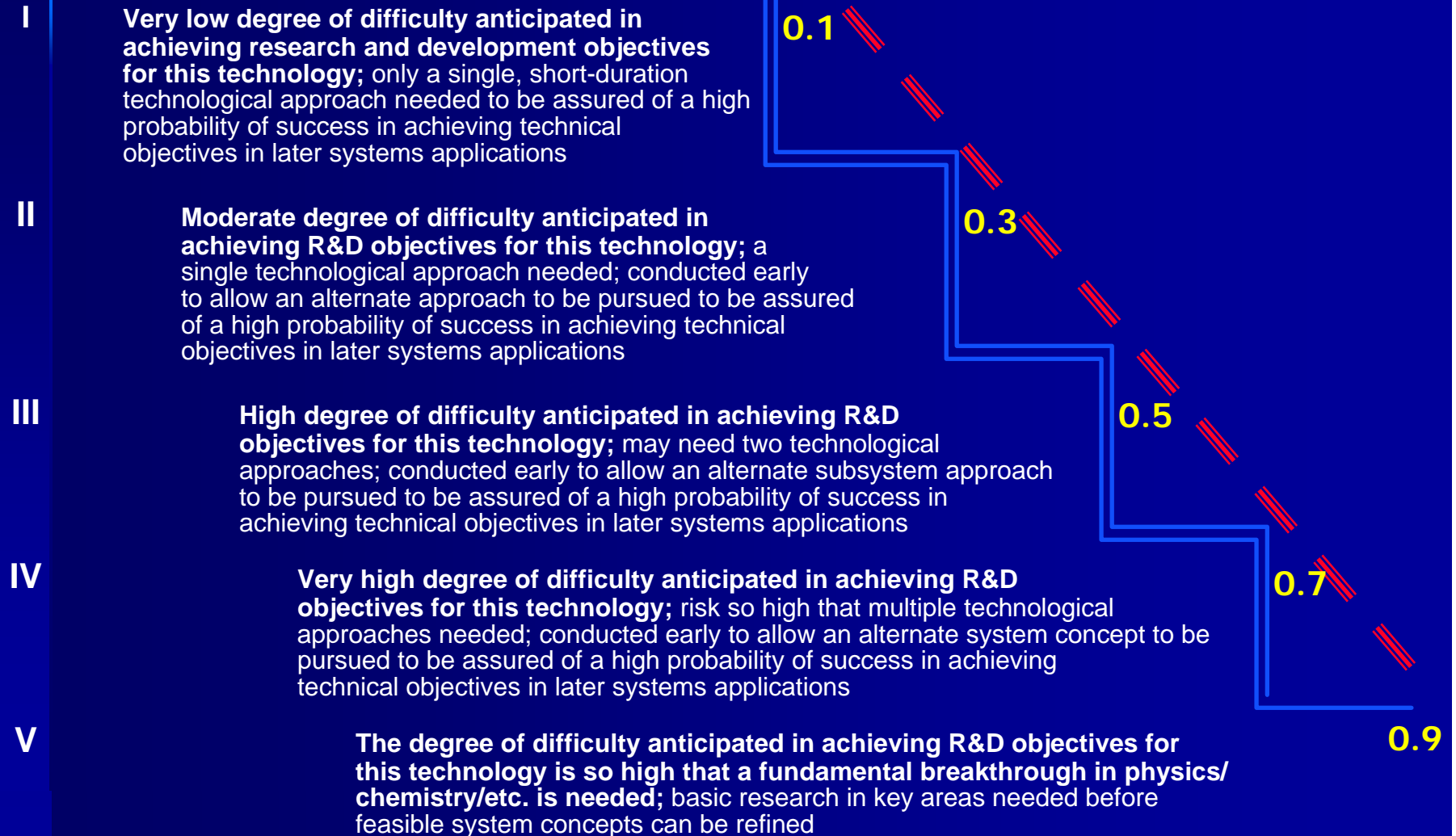
- Maturity, as a One-Dimensional Metric, is NOT Adequate to Determine Technology Transition Readiness
- Unmet Performance is NOT Adequate Risk Measure
- The Amount of Risk Associated with Each Requirement, or a Composite Risk at the System Level, Must Be Incorporated to Provide Realistic and **Quantitative** Risk Measure.



# Degree of Difficulty

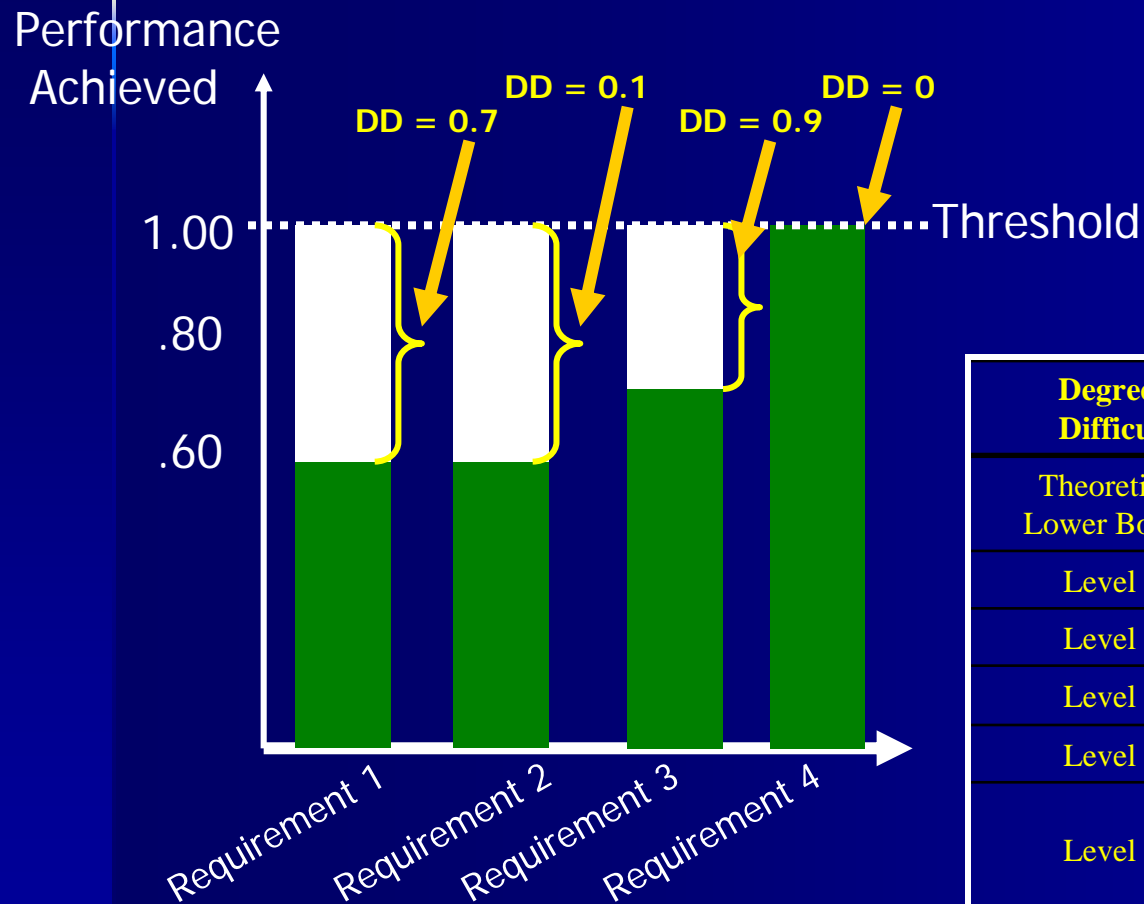
## DESCRIPTION

*Mankins, 1998 & 2002*



Technology Performance Risk Measure

# Hypothetical Example



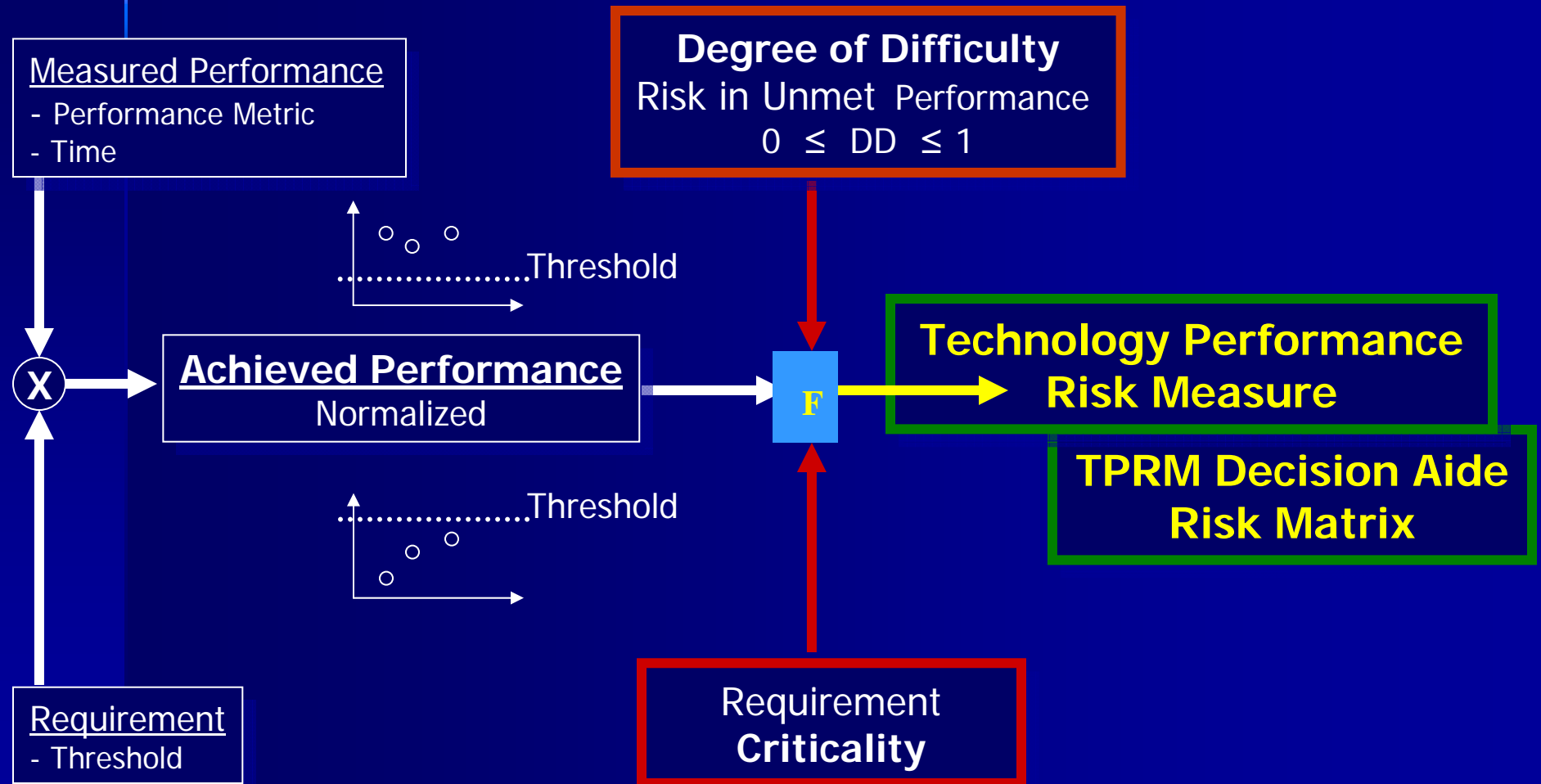
Degree of Difficulty	Risk Level	DD Value
Theoretical Lower Bound	No Risk; Guaranteed Success	0.0
Level 1	Very Low Risk	0.1
Level 2	Low Risk	0.3
Level 3	Medium Risk	0.5
Level 4	High Risk	0.7
Level 5	Very High Risk, Requiring Fundamental Breakthrough	0.9
Theoretical Upper Bound	Guaranteed Failure	1.0



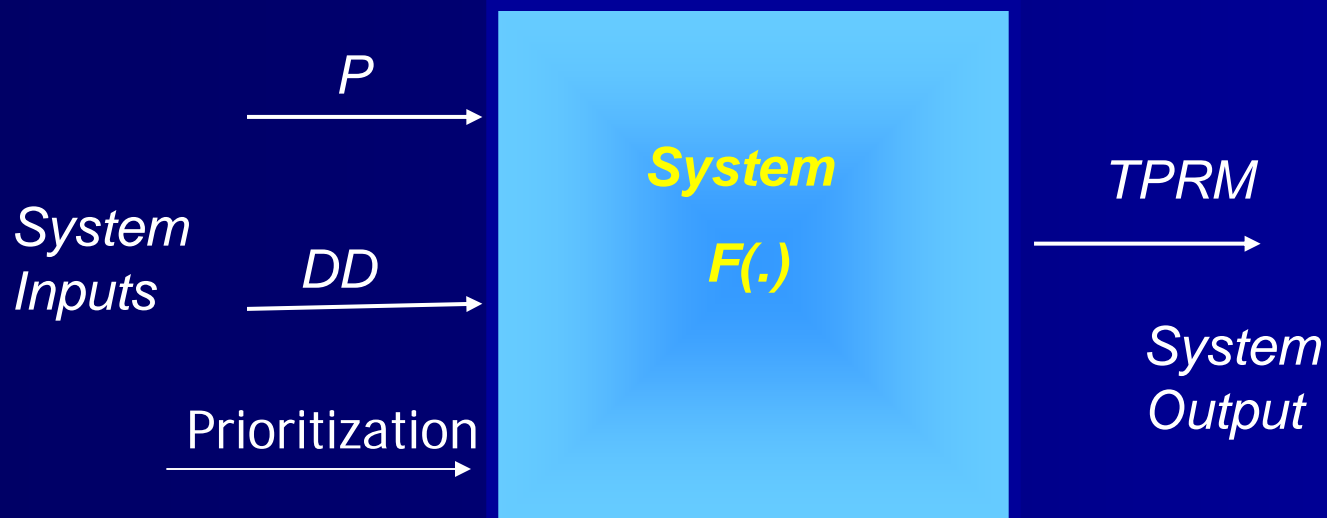
# Key Assumptions

- Acquisitionist and Technologist Reach Agreement Regarding Technical Performance Measures
- Technical Performance Measures Provide Sufficient Quality-Level Requirements to Measure Progress
- The Degree of Difficulty Numerical Assignments Provide Sufficient Measure and Distinction of Performance Risk As the TPM Threshold is Achieved, the Technology has Moved into the Acceptable Performance Region
- As the TPM Threshold is Achieved, the Technology has Moved into the Acceptable Performance Region

# Technology Performance Risk Measure Methodology



# System Block Diagram

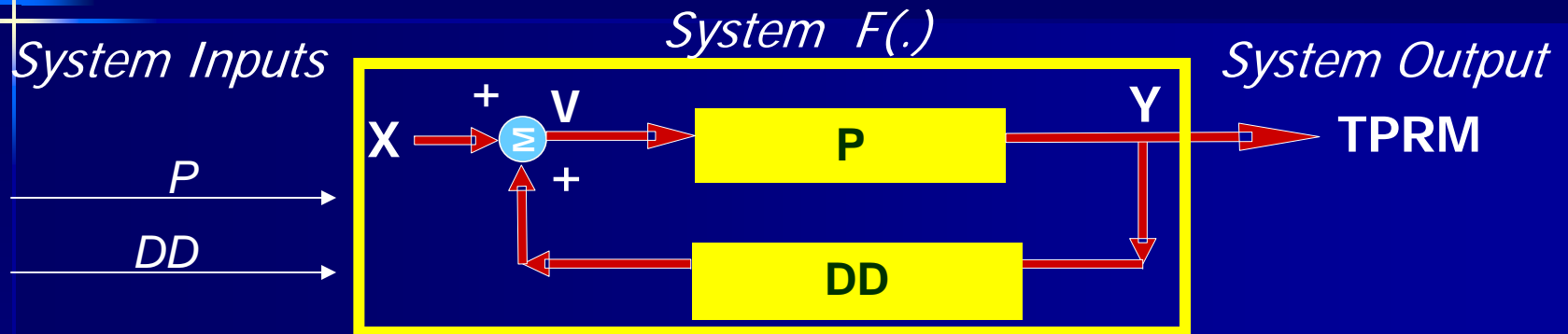


$$TPRM = \lim_{DD \rightarrow 0} \{F(P; DD)\} = (1 - P)$$

$$TPRM = \lim_{P \rightarrow 1} \{F(P; DD)\} = 0$$

# Technology Performance Risk Measure

## Mathematical Model



$$Y = V * P$$

$$V = X + Y * DD$$

$$X = (1-P)/P$$

By substituting for  $V$ ,

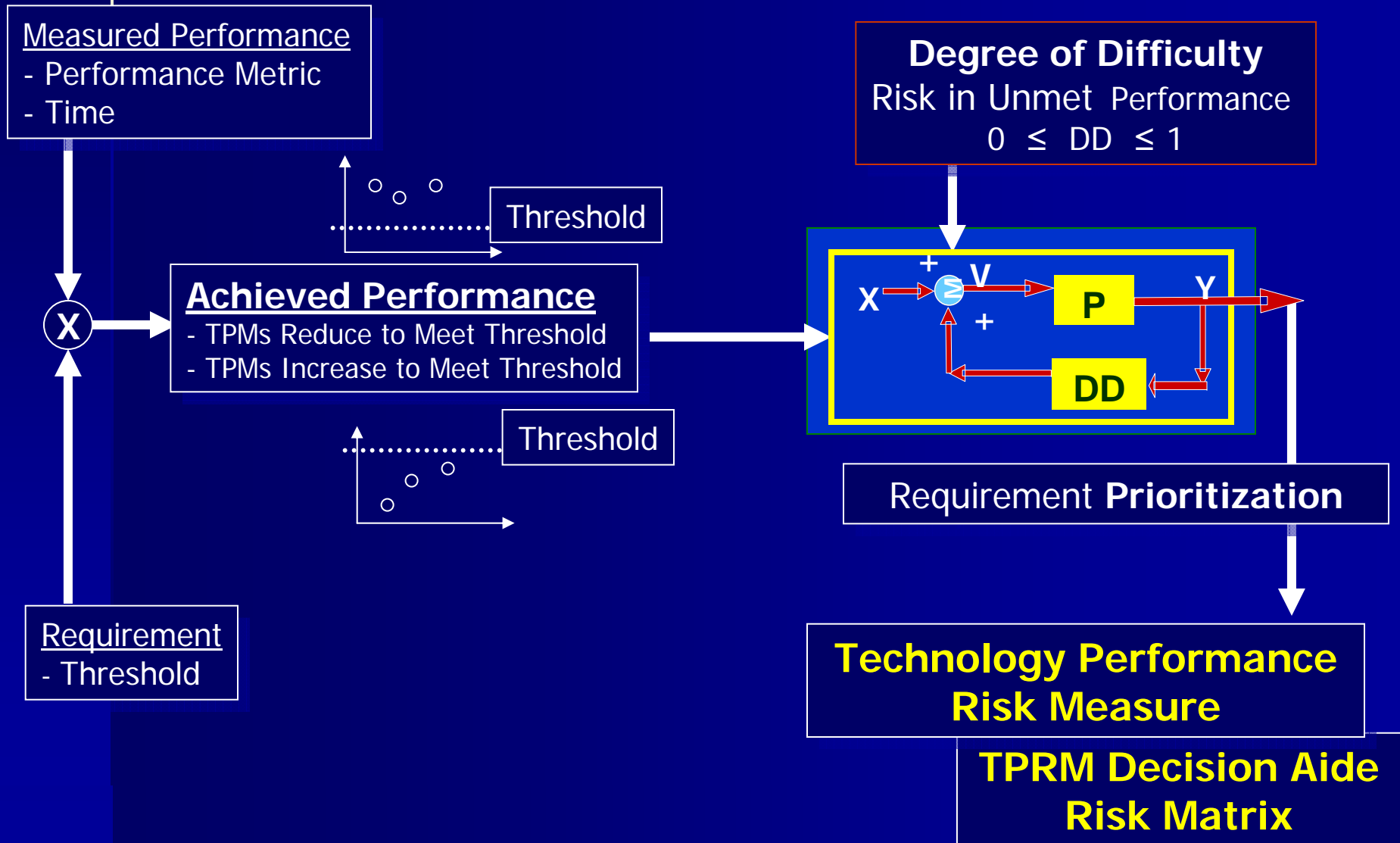
$$Y = (X + Y * DD) * P$$

$$Y = [(1-P)/P] * P + Y * DD * P$$

$$Y(1-DD * P) = [(1-P)/P] * P$$

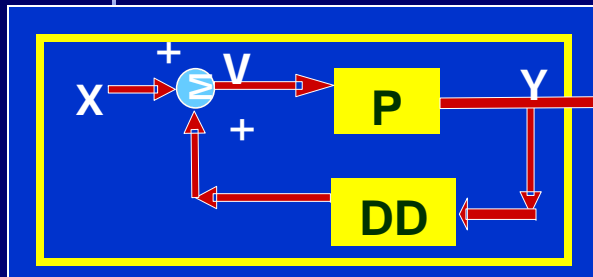
$$Y = (1-P)/(1-P * DD) = TPRM$$

# Technology Performance Risk Measure Methodology



# Technology Performance Risk Measure

## Mathematical Model



$$TPRM = (1-P) / (1-P*DD)$$

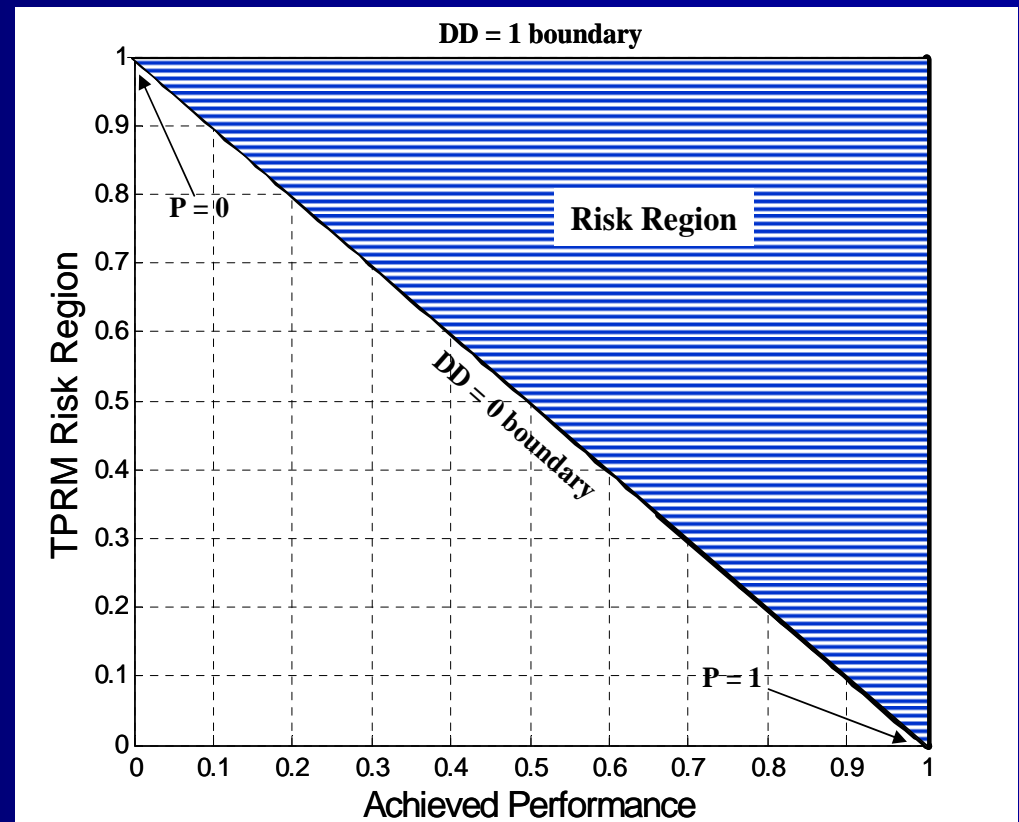
### Boundary Conditions

$$TPRM = \lim_{DD \rightarrow 1} \{ F(P; DD) \} = 1$$

$$TPRM = \lim_{DD \rightarrow 0} \{ F(P; DD) \} = (1-P)$$

$$TPRM = \lim_{P \rightarrow 0} \{ F(P; DD) \} = 1$$

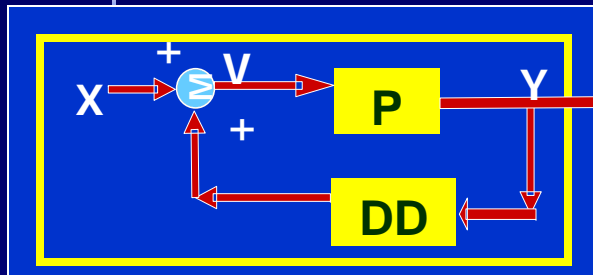
$$TPRM = \lim_{P \rightarrow 1} \{ F(P; DD) \} = 0$$



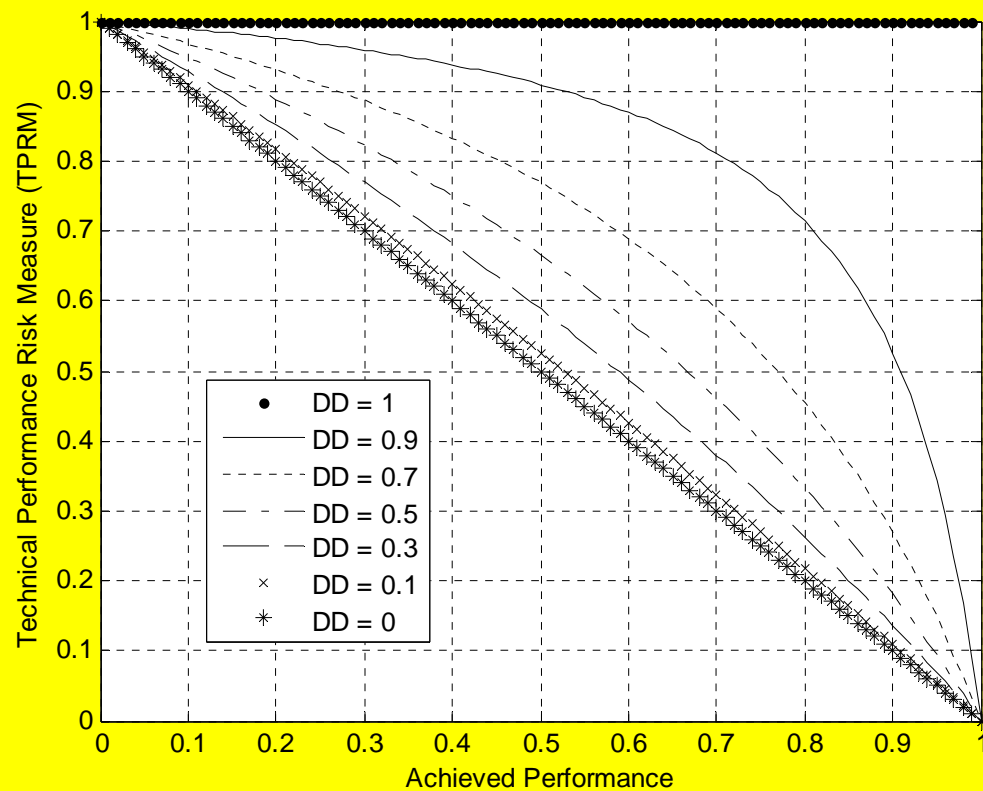


# Technology Performance Risk Measure

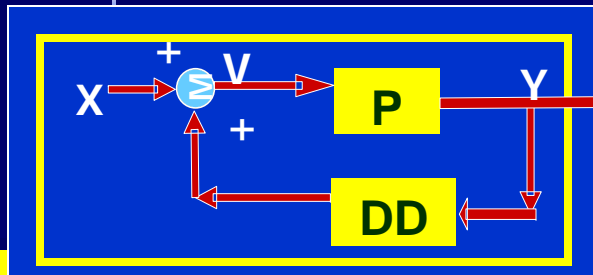
## Degree of Difficulty as Parameter



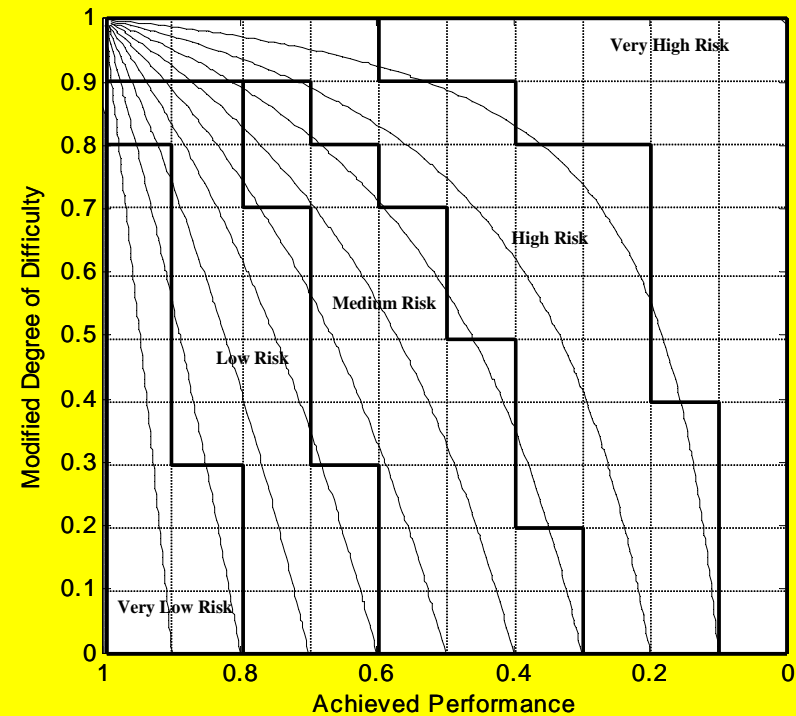
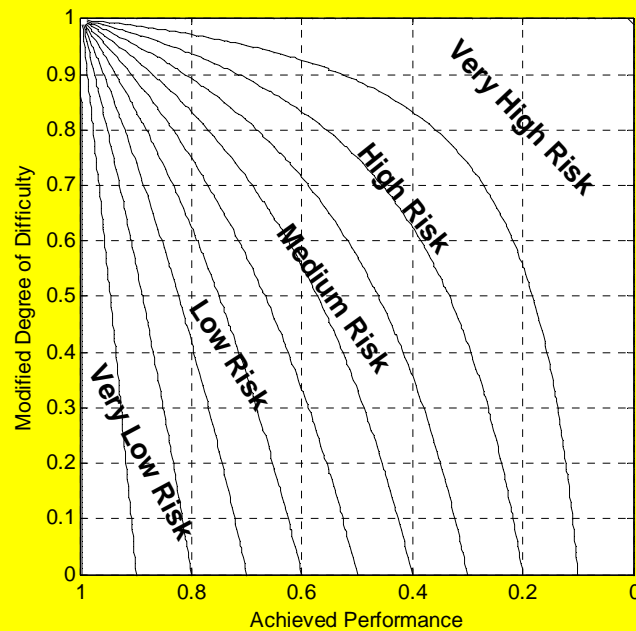
$$\text{TPRM} = (1-P) / (1-P*DD)$$



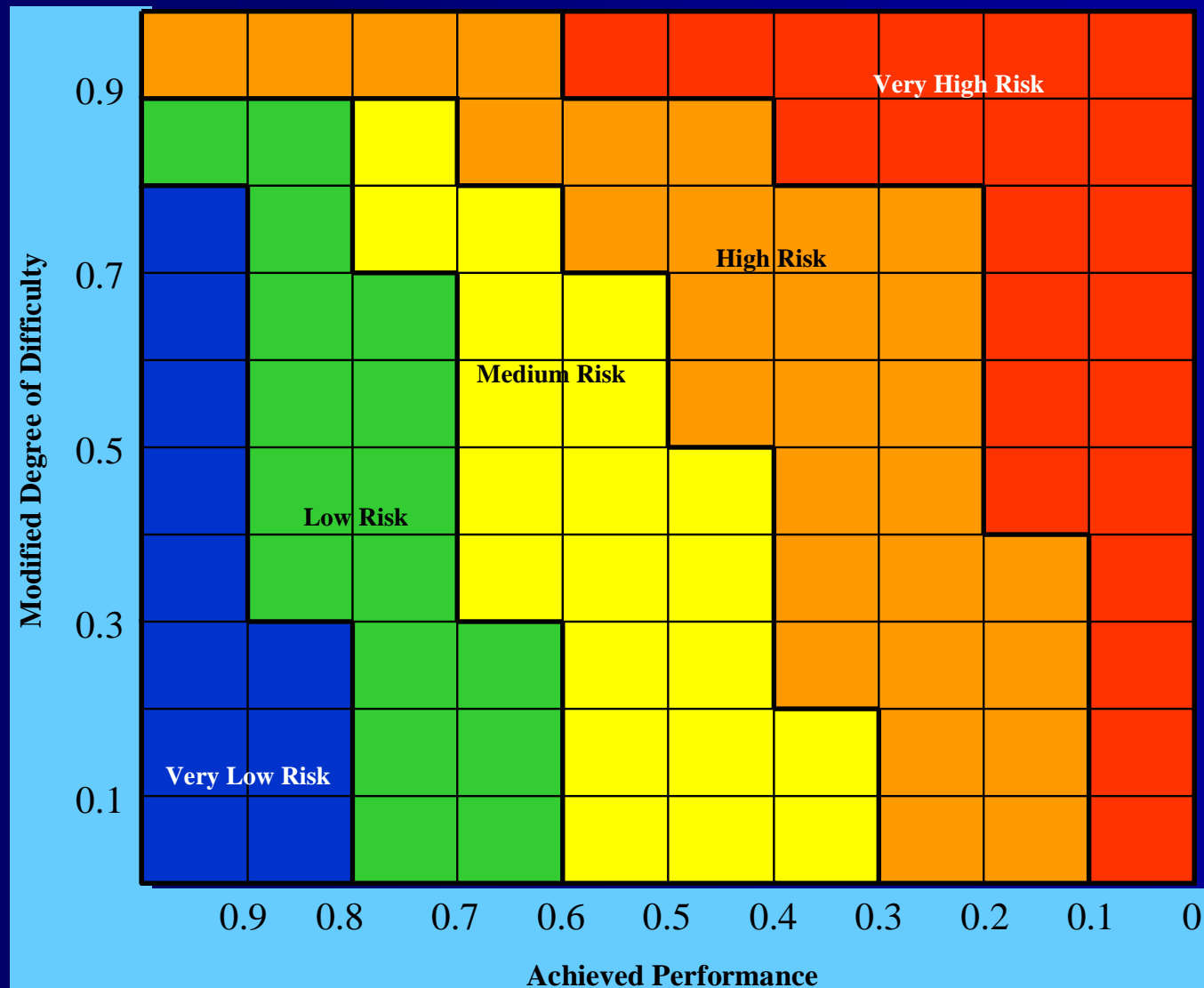
# TPRM Risk Regions



$$TPRM = (1-P) / (1-P*DD)$$



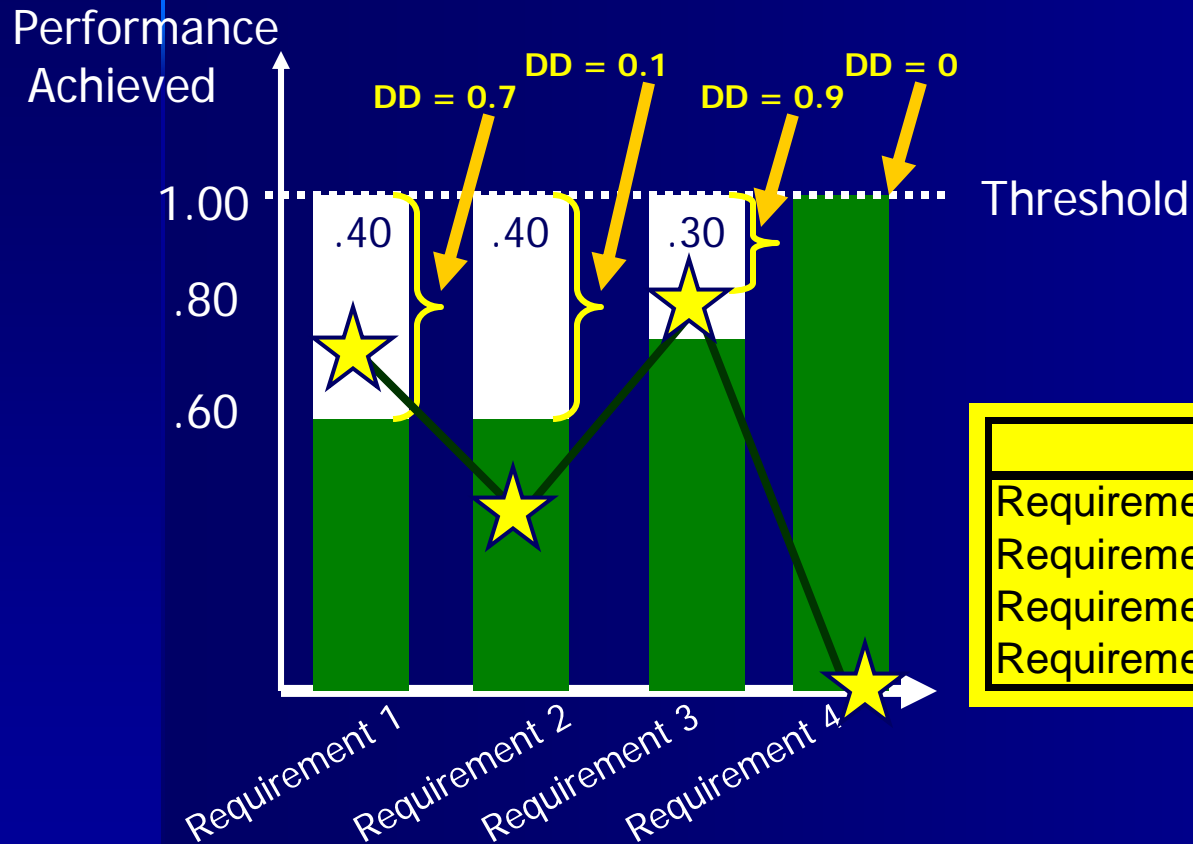
# TPRM Decision Aide Risk Matrix



Technology Performance Risk Measure

# Technology Performance Risk Measure

## Hypothetical Example

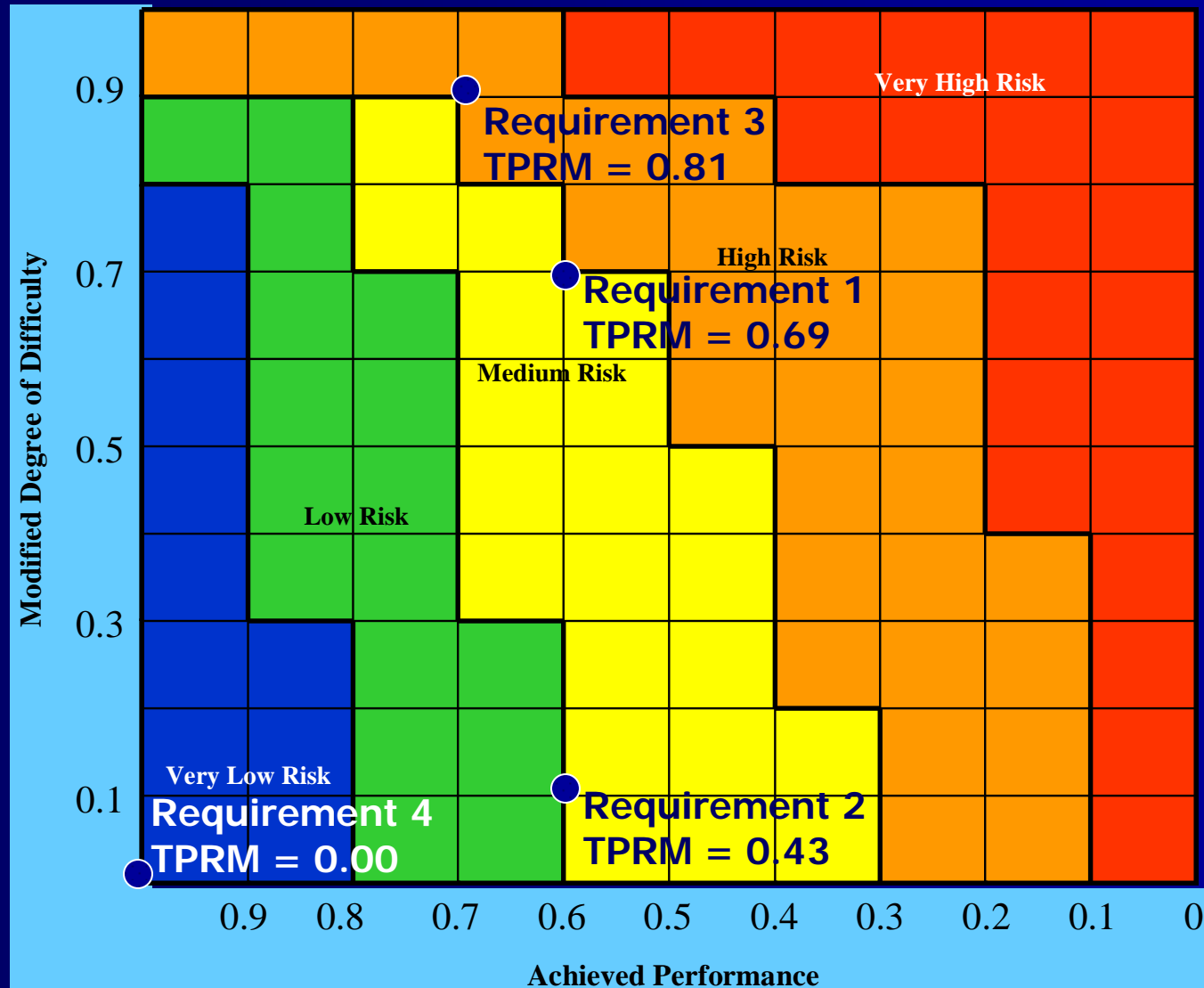


	P	DD	TPRM
Requirement 1	0.6	0.7	0.69
Requirement 2	0.6	0.1	0.43
Requirement 3	0.7	0.9	0.81
Requirement 4	1	N/A	0.00

Aggregated TPRM = 0.48

# TPRM Decision Aide Risk Matrix

## Hypothetical Example



Technology Performance Risk Measure

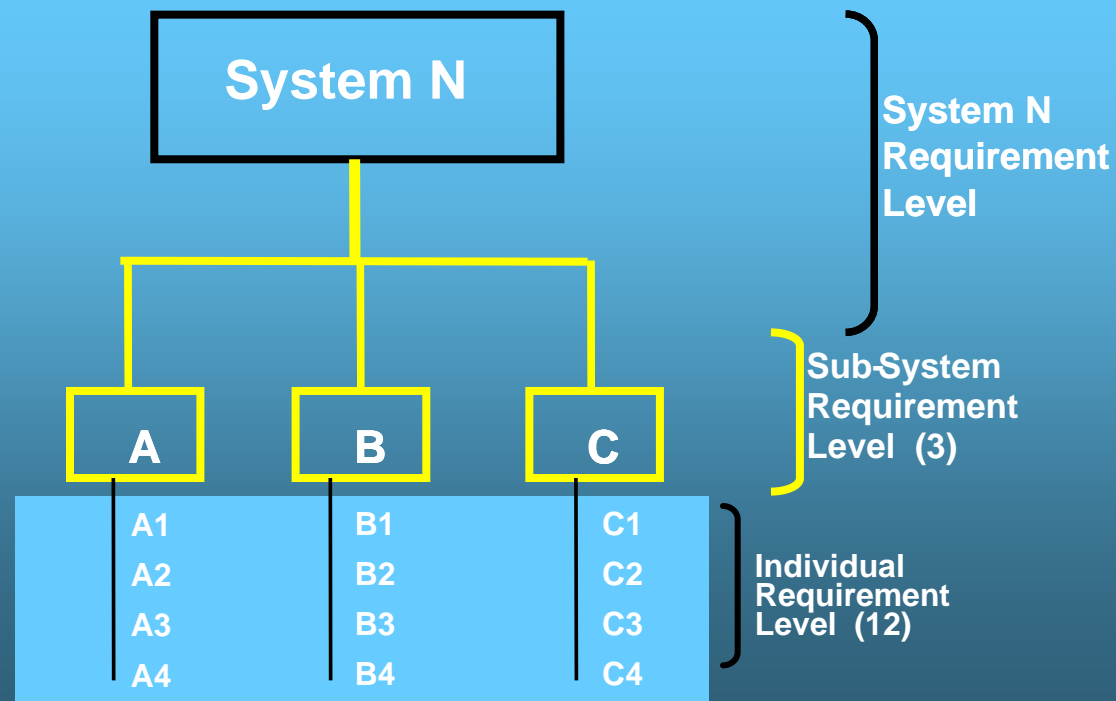


# TPRM Success Criterion

TPRM Transition Recommendation		Program Impact	TPRM Successful?
Yes		Greater than 15% cost over run and/or greater than 6 months schedule delay	No
No		Greater than 15% cost over run and/or greater than 6 months schedule delay	Yes

# Technology Performance Risk Measure

System N: System Architecture



# Technology Performance Risk Measure

## Case Study – System N

Sub-System	Requirements	Achieved Performance	Degree of Difficulty	Individual Requirement TPRM	Rank Reciprocal Weights	Subsystem Level TPRM	
A	A1	0.48	0.70	0.79	0.08	0.12	0.59
	A2	0.86	0.90	0.62	0.06		
	A3	1.00	0.00	0.00	0.04		
	A4	0.39	0.70	0.84	0.05		
B	B1	1.00	0.00	0.00	0.32	0.00	
	B2	1.00	0.00	0.00	0.16		
	B3	1.00	0.00	0.00	0.05		
	B4	1.00	0.00	0.00	0.11		
C	C1	1.00	0.00	0.00	0.03	0.05	0.45
	C2	0.46	0.90	0.92	0.04		
	C3	0.98	0.70	0.06	0.03		
	C4	0.63	0.70	0.67	0.03		

$$\text{TPRM (System N)} = 0.17$$

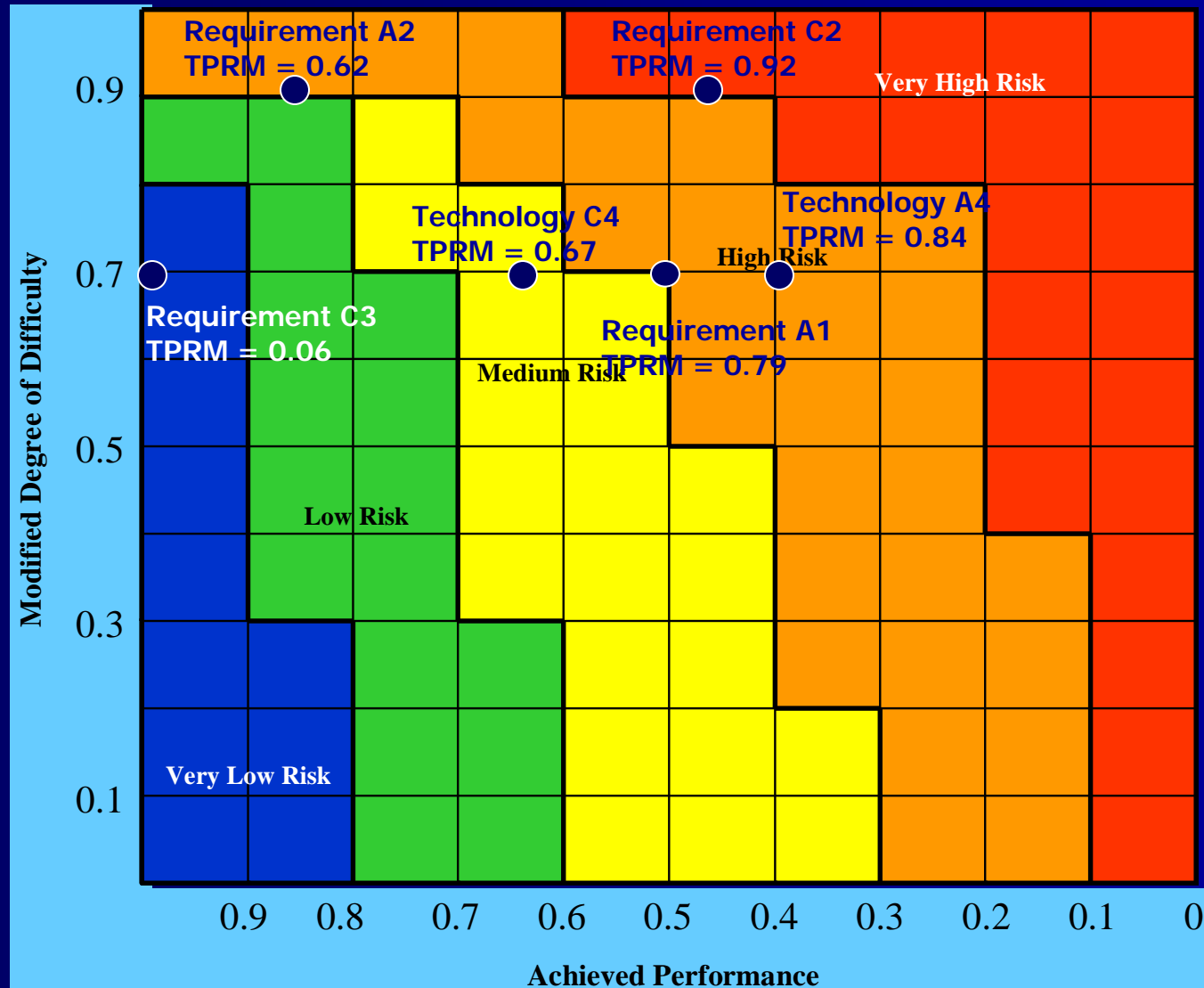
**Government Decision: Continue Development but do not Transition.**

**TPRM Agrees with Government Decision to Continue Technology Development. Do not Transition Since Risk for Individual Requirements within Sub-Systems A and C Remains High**



# TPRM Decision Aide Risk Matrix

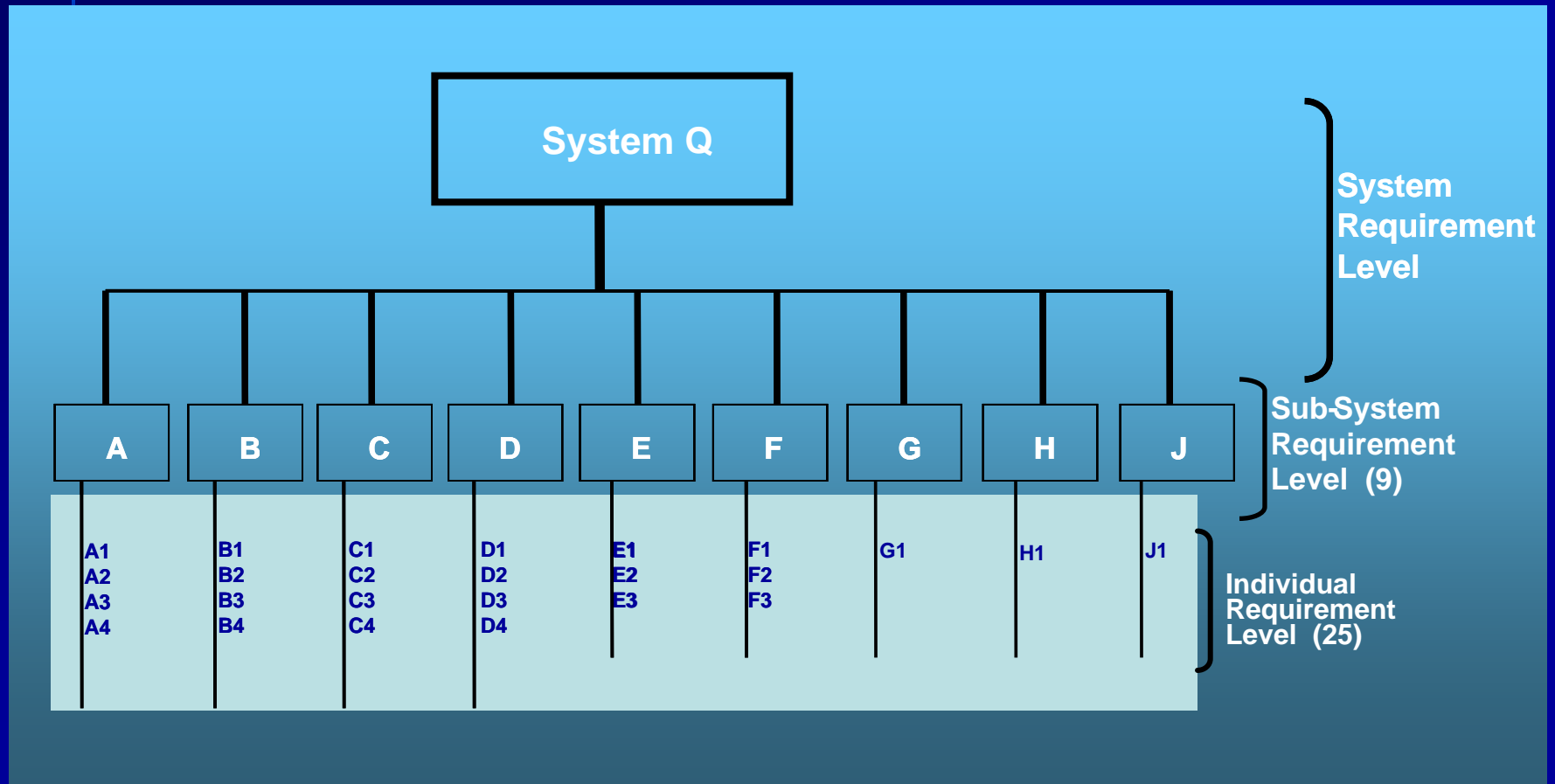
## Case Study – System N



# Technology Performance Risk Measure

## System Q: System Architecture

### Evaluation of 2 Technologies

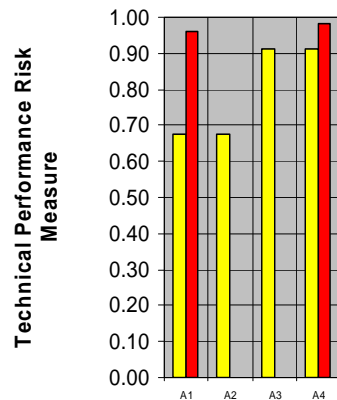


# Technology Performance Risk Measure

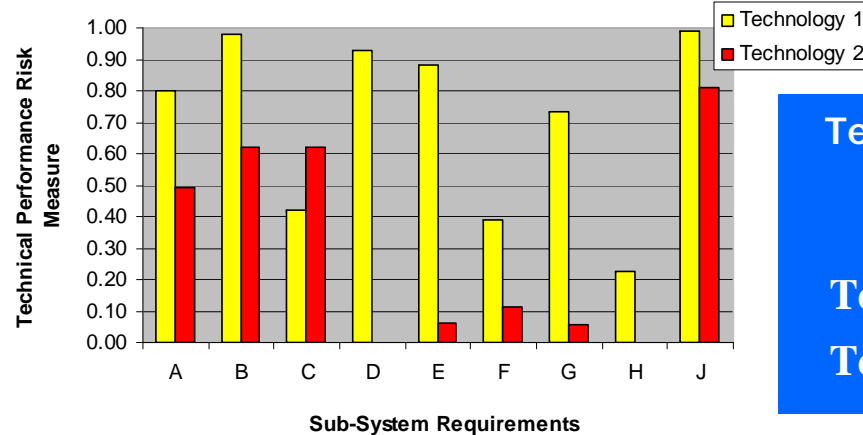
## System Q: Technology Comparisons

	Requirement	Performance Achieved	Unmet Performance RISK INDEX	Degree of Difficulty	TPRM Individual Requirement	Rank Reciprocal Weight	TPRM Sub-System Level
Technology 1	A1	0.49	0.51	0.5	0.68	1.72	0.80
	A2	0.49	0.51	0.5	0.68	1.97	
	A3	0.24	0.76	0.7	0.91	1.83	
	A4	0.24	0.76	0.7	0.91	2.12	
Technology 2	A1	0.29	0.71	0.9	0.96	1.72	0.49
	A2	1	0	0	0.00	1.97	
	A3	1	0	0	0.00	1.83	
	A4	0.16	0.84	0.9	0.98	2.12	

Technical Performance Risk Measure  
Comparisons of Technologies at Individual Requirement Level



Technical Performance Risk Measure  
Comparisons of Technologies at Sub-System Level



Technology Performance Risk Measure

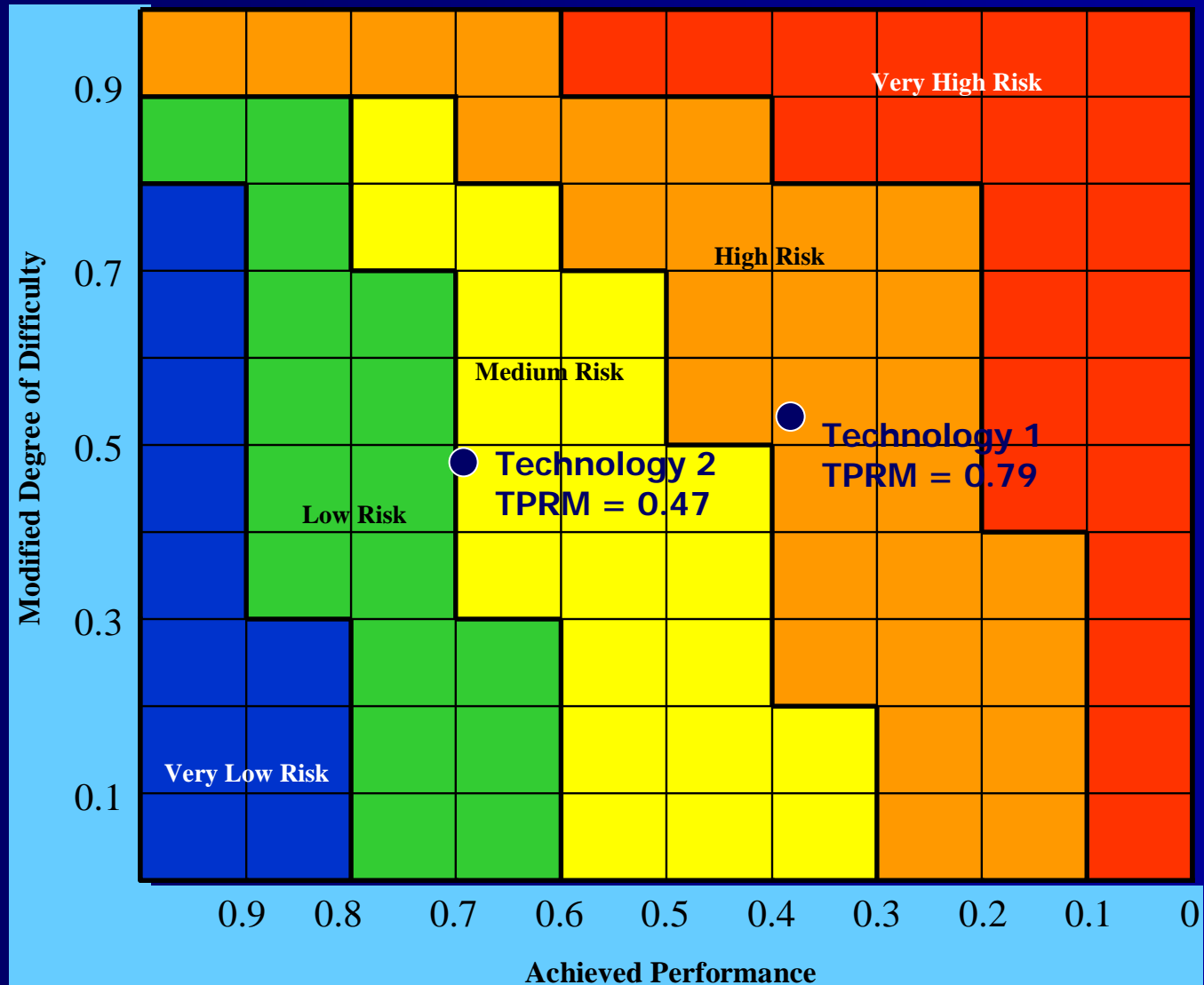
Technology 1 **0.79**

Technology 2 **0.47**

**Government Selected Technology 1**  
**TPRM: Select Technology 2**

# TPRM Decision Aide Risk Matrix

## System Q



Technology Performance Risk Measure

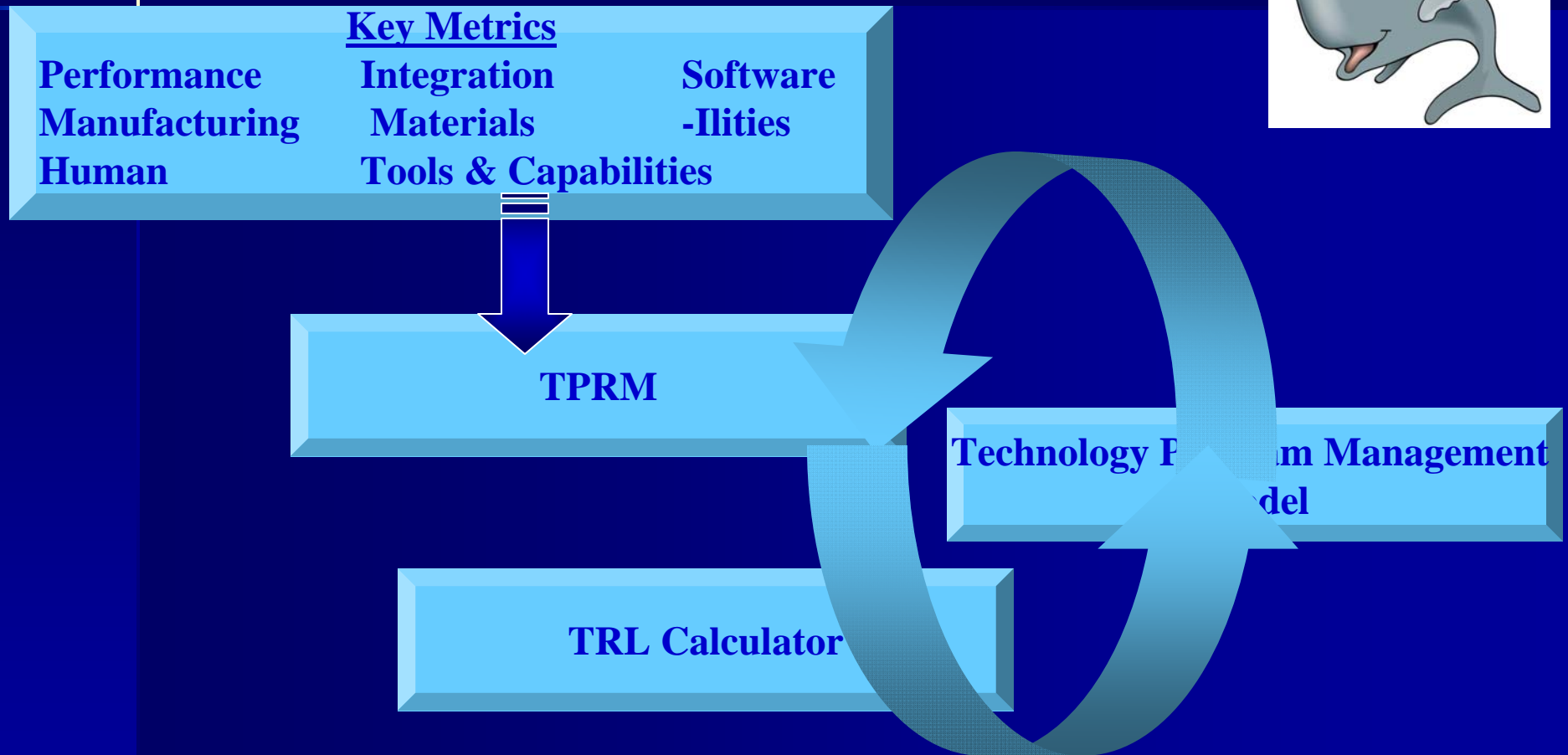
# Technology Performance Risk Measure

## Summary

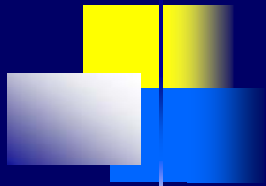


- ✓ Requisite Decision Model
- ✓ Easy to Utilize and Understand
- ✓ TPRM Case Studies Indicated Significant Enhancement in Determination of Technology Transition Readiness Level
- ✓ Flexibility to Apply to Each Level of Technology
  - Individual Requirement Level
  - Sub-System Category Level
  - Total Technology System Level
- ✓ Provides a Quantitative-based Assessment
- ✓ Value-Added Information Regarding Performance Risk to Support Technology Assessment Related Decisions
- ✓ Supports Monitoring of Risks Over Time
- ✓ Supports Prioritization of Resources to Mitigate Identified Risks

# Next Steps....



**Key Metrics Provide Information to Support  
Technology Maturity & Transition Readiness Assessments**



# Questions ?



## Technology Performance Risk Measure

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